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A. N. Severtsov Institute of Animal Evolutionary Morphology and Ecology, USSR Academy of Sciences, Moscow, USSR

# Food requirements of diplopods in the dry steppe subzone of the USSR

B. R. STRIGANOVA, Z. G. PRISHUTOVA

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## 1. Introduction

Diplopods are known to be numerous in steppe soils of the European territory of the USSR. Population densities of diplopods seem to be significant in typical plant communities of meadow steppes. Distribution of these myriapods in southern steppes is restricted by plots with a tree and bush plant cover. Diplopods inhabit the dry subzone valley and ravine forests, shrubberies in relief depressions and field-protecting forest plantations. These habitats represent an optimal environment for this group. Population densities of diplopods were found to reach 400 Ind $\times$ $m^{-2}$ in Ukrainian oak plantations (GHILAROV, 1957). *Rossiulus kessleri* LOHMANDER predominates among diplopods in dry steppe landscapes. This species is widely distributed along the European part of the USSR, from the northern taiga to the Caucasus foothills (STRIGANOVA & GOLOVAČ, 1982).

High population density of *R. kessleri* was recorded in forest steppe and steppe zones. This species sems to be well adapted to abrupt seasonal changes of the hydro-thermal soil conditions and water deficiency during spring-summer period, when copulation and oviposition take place. *R. kessleri* were showed to migrate from forest stands into open habitats during periods of active feeding. They occur regularly in grass plots and field soils near forest plantations (STRIGANOVA, 1972).

Leaf litter seems to represent the main food source of *R. kessleri*. These diplopods were shown to consume additionaly green parts of crop shoots (STRIGANOVA, 1980). Feeding activity of *R. kessleri* was investigated on examples of populations from forest-steppe and meadow steppe habitats. These diplopods occur there both in natural oak forests and oak plantations. Their food rations were experimentally estimated when diplopods were fed with litters of oak and other broadleaved tree species – hornbeam, maple, beech. Mean litter consumption was found to be 11–36% per dry body mass unit (STRIGANOVA, 1977, 1980). *R. kessleri* were fed with a grass litter and dead roots (POKARJEVSKIJ, 1983). Grass litter was found to be consumed as intensively as leaf litter. Daily consumption of dead roots averaged 4–6% per dry mass unit. Thus it is suggested that *R. kessleri* prefers the remains of above ground plant parts.

Data reported here concern investigations of food requirements of *R. kessleri* in dry steppe landscapes near the southern limit of their range.

## 2. Material and methods

Diplopods *R. kessleri* were sampled in field-protecting forest plantations of the Rostov-Don region. The mean population densities of this species were 38–146 Ind. $\times$ $m^{-2}$.

*Fraxinus excelsior* L., *Robina pseudoacacia* L., *Populus nigra* L., are the main tree species forming the plantations. *Armeniaca vulgaris* LAM. occurs as the additional culture in many plantations. Diplopods were found to inhabit plantations with a mixed tree stand and were absent in *Robinia* plantations.

Food preferenda, consumption and assimilation of leaf litters by *R. kessleri* were analysed. Rates of mass growth in juvenile instars of diplopods fed by different types of litters were estimated to evaluate food qualities. Indices of the feeding activity of animals were estimated gravimetrically (STRIGANOVA, 1975).

Diplopods were maintained in the laboratory in 0.5 l glass jars (50 Ind. per jar) with soil and plant litter. The humidity of the litter was maintained at the optimum level. Mean air temperatures were 20–22°C.

Short term estimates of the daily food consumption and food assimilation were carried out on animals individually placed in Petri dishes with litter of known mass. The duration of these experiments was 48 h. Estimates were carried out on 20 replicates. Results are represented in the table 1.

Comparative estimates of growth rates on different kinds of foods lasted during a year. Juvenile diplopods of the 2nd instar were enclosed in experimental jars with soil and different litters. During a year diplopods reached XI-XII instars. Animals were weighed after each moult (table 2).

Food preference was experimentally estimated in round dishes (d = 25 cm). Portions of different litters under consideration were placed along a dish wall at an equivalent distance from each another. Fifty diplopods of the VII instar were placed into the centre of a dish. After 1–2 h diplopods distributed into the litter. Their numbers in each litter were recorded. The experiment was carried out on 21 replicates.

Food preferences were also investigated when diplopods were fed with a mixture of litters. After 2 d the amounts of each litter consumed were recorded.

Feeding activity and growth rates of *R. kessleri* were compared in leaf litters of the above-mentioned tree species, composed mainly of forest stands in steppe plantations. The addition feeding activity on couch-grass *Elytrigia repens* (L.) litter was monitored. This weed occurs both under a canopy of trees and in grass plots and its thought to be utilized by diplopods as a food source.

## 3. Results

Laboratory experiments when diplopods were fed with separate litters revealed the following range of relative (%) food mass ingested:

*Armeniaca* (36.2) – *Fraxinus* (22.0) – *Robinia* (17.9) – *Elytrigia* (15.6) – *Populus* (8.3)

Another preference range was demonstrated in experiments when *R. kessleri* were fed with a mixed litter:

*Fraxinus* (71.7) – *Armeniaca* (13.7) – *Elytrigia* (7.4) – *Robinia* (5.8) – *Populus* (1.4)

The main part of the food consumed was represented by *Fraxinus* litter in the secound experimental series. Leaf falls of *Armeniaca, Elytrigia* and *Robinia* were utilized as additional food sources. The *Populus* litter was consumed in negligible amounts as in the first experiment.

*R. kessleri* were found to consume all available types of litters in spite of a surplus of preferred food sources. This was observed earlier on diplopods species from temperate broad-leaved forests fed on a number of leaf litters (STRIGANOVA, 1969).

Table 1 shows a negative correlation between consumption rates and assimilitation efficiences of different plant remains. The highest values for assimilation efficiency were found to be characteristic for *Elytrigia* and *Populus*. Amount of an assimilated matter per mass unit was the highest when *R. kessleri* fed on the *Elytrigia* litter. Actual ration in the *Populus* litter was as high as those in other types of litters.

High assimilation of the couch-grass litter showed the capacity of diplopods to feed on cereals side by side with a leaf litter. Feeding of *R. kessleri* on cereals reported in previous papers can be explained not only by water deficiency in a forest litter. This food source appeared to have a high nutritional quality. Diplopods switch to living grass (or crop) tissues as the litter and upper soil horizon dry.

Rates of the body mass increase and development were found to indicate food quality. For example, individuals of the same instar of *Orthomorpha gracilis* maintained in 2 food sources differed widely in mass, because of the different protein content in food sources (KHEIRALLAH, 1978).

*R. kessleri* were maintained during a year in jars with different litters. Initial mean body mass of juveniles of the 2nd instar was 0.6–0.8 mg. During the year diplopods reached XI–XII instar. Mass differences of a body appeared already in the 3rd instar. Rates of the growth revealed a differentiation of litters in 2 groups: *Fraxinus* and *Armeniaca* litters represented food sources with high nutritional qualities, whereas rates of the growth in other kinds of litters were significantly lower (table 2). Mass increase of initial instars in the *Robinia* litter was low, but diplopods of the XI and XIII instars reached the same mass values when reared on this food as those in a mixed litter.

Table 1. Feeding activity of diplopods *Rossiulus kessleri* in different litters.

| Litters | Mean dry mass of animals [mg] | Consumption per day | | Assimilation | Assimilated matter |
|---|---|---|---|---|---|
| | | mg × Ind.$^{-1}$ | mg × mg$^{-1}$ $m_\times$ of animals[1] | efficiency [%] | mg × mg$^{-1}$ $m_\times$ |
| *Fraxinus excelsior* | 301.6 ± 6.1 | 78.4 ± 2.7 | 26.4 ± 1.2 | 25.3 ± 1.1 | 6.6 ± 0.3 |
| *Armeniaca vulgaris* | 304.6 ± 5.9 | 75.0 ± 2.5 | 24.8 ± 0.8 | 11.4 ± 1.0 | 2.7 ± 0.2 |
| *Robinia pseudoacacia* | 300.6 ± 7.7 | 57.5 ± 3.5 | 19.1 ± 0.8 | 18.1 ± 1.2 | 3.4 ± 0.2 |
| *Elytrigia repens* | 303.6 ± 7.5 | 41.5 ± 1.5 | 13.9 ± 0.6 | 73.3 ± 1.2 | 10.0 ± 0.4 |
| *Populus nigra* | 302.8 ± 5.2 | 23.3 ± 2.3 | 7.6 ± 0.7 | 45.9 ± 2.1 | 3.3 ± 1.5 |
| mixed litter | 300.6 ± 7.0 | 49.3 ± 1.8 | 16.5 ± 0.7 | 18.5 ± 1.6 | 3.0 ± 0.3 |

[1] $m_\times$ = xero-mass = dry mass.

Table 2. Growth rates of *Rossiulus kessleri* in different leaf litters.

| Instars | *Fraxinus excelsior* | *Armeniaca vulgaris* | *Robinia pseudoacacia* | *Elytrigia repens* | *Populus nigra* | mixed litter |
|---|---|---|---|---|---|---|
| III | 1.8 ± 0.1 | 1.7 ± 0.1 | 1.1 ± 0.1 | 1.2 ± 0.1 | 1.2 ± 0.1 | 1.8 ± 0.1 |
| IV | 3.5 ± 0.1 | 2.8 ± 0.1 | 2.2 ± 0.1 | 2.4 ± 0.1 | 1.9 ± 0.1 | 3.8 ± 0.1 |
| V | 7.2 ± 0.1 | 4.9 ± 0.2 | 3.7 ± 0.1 | 4.1 ± 0.1 | 3.3 ± 0.1 | 5.7 ± 0.1 |
| VI | 10.7 ± 0.4 | 7.9 ± 0.3 | 7.7 ± 0.3 | 7.0 ± 0.2 | 7.1 ± 0.2 | 10.0 ± 0.2 |
| VII | 18.2 ± 0.4 | 17.0 ± 0.4 | 12.9 ± 0.6 | 11.7 ± 0.3 | 9.9 ± 0.4 | 17.4 ± 0.4 |
| VIII | 25.7 ± 0.6 | 25.1 ± 0.8 | 16.7 ± 0.5 | 18.5 ± 2.6 | 13.0 ± 0.6 | 24.8 ± 0.6 |
| IX | 42.5 ± 1.4 | 34.8 ± 1.2 | 29.1 ± 1.4 | 22.8 ± 1.2 | 20.3 ± 0.5 | 35.6 ± 1.0 |
| X | 59.5 ± 1.9 | 57.2 ± 2.6 | 44.1 ± 2.4 | 37.0 ± 3.6 | 25.8 ± 2.5 | 51.1 ± 2.2 |
| XI | 80.2 ± 3.1 | 80.5 ± 2.5 | 67.1 ± 2.3 | 54.1 ± 3.1 | 39.0 ± 2.5 | 67.5 ± 2.3 |
| XII | 121.9 ± 22.3 | 98.7 ± 4.3 | 81.6 ± 3.7 | – | 46.8 ± 3.1 | 87.2 ± 2.6 |

Body mass of diplopods fed with *Populus* and *Elytrigia* reached a half of that in other litters. Diplopods fed with *Elytrigia* did not survive after the XI instar because of a shortage of necessary nutrients.

## 4. Conclusions

*R. kessleri* widely distributed in the steppe zone, have obligatory trophic relations with a tree leaf litter. Diplopods utilize grass litter and living grass tissues as well, but they need the tree litter for normal growth and attainment of maturity. *R. kessleri* revealed clearly expressed food preferenda in relation to some litter species, although they utilize a wide spectrum of available plant remains.

Leaf fall of *Fraxinus* and *Armeniaca* and, to a lesser extent, that of *Robinia* represent the most suitable food sources. These tree species are the characteristic components of field-protecting plantations in the dry stepe subzone. Diplopods under a tree canopy actively participate in the reduction of forest litter and represent the most numerous group of primary decomposers in that region. High activity of these invertebrates supports the balance between the accumulation and mineralization of organic remains in the soil. This seems to increase the stability of artificial island forest ecosystems in dry steppes.

Feeding requirements of diplopods have to be taken into account in designing artificial forest plantations. Tree species preferred by diplopods as a food source must be used for plantations. This will promote the distribution of diplopods in dry steppes and support their stable populations in forest plots.

## 5. Zusammenfassung


**Nahrungsbedarf von Diplopoden in der Trocken-Steppen-Subzone der UdSSR**

Unter Laborbedingungen wurden (bei unterschiedlichem Nahrungsangebot) die Freßaktivität und der Massenzuwachs von *Rossiulus kessleri* LOHM. (Julidae, Diplopoda) untersucht. Diese Diplopoden-Art ist in der Steppenzone des europäischen Teils der UdSSR weit verbreitet. Die Versuchs-Tiere stammen aus Schutzwäldern der trocken Südsteppen und ernähren sich naturgemäß von Nekromasse aus der Baum-, Strauch-, Kraut- und Gras-Schicht. Bei differenziertem Nahrungsangebot zeigten die Tiere deutliche Präferenzen: Laubstreu von in den Schutzwäldern weitverbreiteten Bäumen der Gattungen *Fraxinus* und *Armeniaca* wurden bevorzugt. Die räumliche Verbreiterung von *R. kessleri* sowie der Wechsel ihrer Populations-Dichten und Biomassen in den Trockensteppen wird im Zusammenhang mit Unterschieden des Baumarten-Bestandes diskutiert.



**Schlüsselwörter:** Diplopoden, *Rossiulus kessleri*, Trocken-Steppen Detritus, Nahrungs-Präferenz, Assimilations-Raten, Massenzuwachs.


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**Synopsis:** *Original scientific paper*

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Feeding activity of the diplopod *Rossiulus kessleri* LOHM. (Julidae, Diplopoda), predominating in the steppe zone of the European part of the USSR is considered. Diplopods are found to utilize a number of leaf and grass litters and show clearly expressed food preferenda. Growth rates and terminal sizes of diplods differ widely on separate food sources under experimental conditions. Distribution of *R. kessleri*, their population densities and biomass in relation to the composition of field-protecting forest plantations, are discussed.

**Key words:** diplopods, food preferenda, assimilation efficiency, growth rate.

**Address of the authors:** Institut évoljucionnoj morfologii i ékologii životnych, AN SSSR, (Institut of Animal Evolutionary Morphology and Ecology) Leninskij prospekt 33, Moskva V-71 (Moscow V-71), SU-117071 (corresponding author: Prof. Dr. B. R. STRIGANOVA).